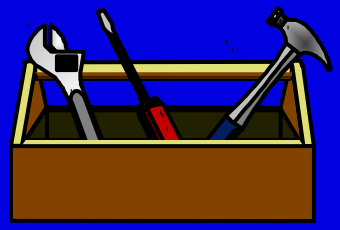
DESIGN A VERTICAL CONSTRUCTION PROJECT

The purpose of this lesson is to provide you with the fundamental knowledge to design a temporary facility that is structurally sound.



TERMINAL LEARNING OBJECTIVE:

- Provided a vertical construction mission, a scientific calculator, a survey set general purpose (GP), soil test set, and references, design a vertical construction project to safely support all calculated loads per the references.

ENABLING LEARNING OBJECTIVES:

- (1) Given a vertical construction mission, a scientific calculator, and references, calculate all dead loads for the proposed structure per TM 5-809-1. (1361-SRVY-2001a)

- (2) Given a vertical construction mission, a scientific calculator, and references, calculate all live loads for the proposed structure TM 5-809-1. (1361-SRVY-2001b)

ENABLING LEARNING OBJECTIVES CONTINUED:

- (3) Given a vertical construction mission, calculated loads, a scientific calculator, and references, design the structural foundation requirements to support the proposed structure per FM 5-428. (1361-SRVY-2001c)

- (4) Given a vertical construction mission, calculated loads, a scientific calculator, and references, design the structural framing requirements for the proposed structure per TM 5-426. (1361-SRVY-2001d)

ENABLING LEARNING OBJECTIVES CONTINUED:

- (5) Given a vertical construction mission, calculated loads, a scientific calculator, and references, identify finish materials for the proposed structure per TM 5-426. (1361-SRVY-2001e)

- (6)Given a vertical construction mission, calculated loads, finished design sketches, a computer, software applications, and references, create project design
- specifications for the proposed structure per TM 5-581B. (1361-SRVY-2001f)

METHOD AND MEDIA

- **Lecture**
  - **–Slides, Dry Erase Board,**
- **Demonstration**
- **Practical Exercises**

ADMINISTRATIVE INSTRUCTIONS

- Instructional Rating Forms (IRF)
  - Hand them over at the end of the examination

EVALUATION

- A closed book written and performance examination covering the materials in this lesson will be administered at the end of this period of instruction.

- 80% or higher is required to show mastery of the material.

SAFETY

- FIRE
- TORNADO

3 Phases of Construction

- Design Phase
- Planning Phase
- Construction Phase

DESIGN PHASE

- The design phase is the initial step in the successful development of a project. Design involves the transfer of basic sketches into final working drawings, and the creation of project specifications which guide the construction work for the intended structure. Design activities can be either informal or formal.

  - Informal design happens when a project is developed without the use of a formal plan.

  - Formal design involves the calculation of all structural loads, designing all structural components of the structure, identifying all finish materials, development of design sketches, and the creation of design project specifications. A complete set of working drawings must be prepared before the actual construction can begin and given to the Combat Engineer Chief.

PLANNING PHASE

- The planning phase normally begins after the design phase has been completed.
  - During this phase of the project, material estimates are compiled from the working drawings, critical path diagrams are developed to help identify the logical sequence of work activities so the project is completed on schedule, and resources such as man power and equipment are identified for each activity in the construction process.

CONSTRUCTION PHASE

- During this phase, the actual construction work begins. Working design specifications and drawings are provided to each party involved in the construction of the project. The construction phase has 4 major components:
  - Site Work/Excavation. (Heavy Equipment)
  - Concrete/Masonry work. (Combat Engineers)
  - Carpentry/Finish work. (Combat Engineers)
  - Electrical/Plumbing work. (Utilities)

BUILDING CODES

- Collection of laws that establish minimum acceptable building standards.
- Codes are used as the basis of structural design.
- Building Codes control the design, construction methods, and the materials to be used to construct the structure.

QUESTIONS?

DEMONSTRATION

Concrete

CONCRETE COMPOSITION

- **Concrete is a mixture of aggregate, Portland cement, and water.**
  - **Aggregate: Filler materials (usually sand, stone or gravel) make up between 60 and 80 percent of the volume of concrete.**
  - **Portland Cement: This is a carefully proportioned and specially processed chemical combination of lime, silica, iron oxide, and alumina.**
  - **Water: The basic ratio of cement to water determines the strength of the concrete. The less water that is added to the mix, the stronger, more durable, and watertight the concrete will be. The more water that is added to the concrete mix results in a concrete that is weaker and more porous.**

HYDRATION

- A chemical reaction between the Portland cement and water causes the concrete to harden, this process is called Hydration.

- Hydration causes concrete to cure and harden, not air drying.

TYPES OF CONCRETE

- **There are two types of concrete:**
  - **Plain concrete: Concrete that is not reinforced, and does not carry heavy loads. Normally used for sidewalks, and driveways.**
  - **Reinforced concrete: Concrete that contains some type of reinforcement steel to absorb tensile and shearing stresses. This type of concrete is subjected to heavier loads.**

CONCRETE STRENGTH

- Concrete has a very high compressive strength which is reached at 28 days after being poured and allowed to cure.

- Concrete's ability to resist stretching, bending, or twisting (tensile strength) is very low.

- Because of concrete's low tensile strength, it must be reinforced with steel bars or wire mesh. This type of reinforcement is required in beams, girders, footings, lintels, walls, and columns.

QUESTIONS?

DEMONSTRATION

Concrete Masonry Unit (CMU)

CONCRETE MASONRY UNITS

- Concrete masonry units (CMU) comply with safety and durability when its use is properly designed.

- Concrete block CMU are used for:
  - Exterior/Interior load-bearing walls.
  - Piers and columns.
  - Retaining walls.

- CMU Nominal size: 8” x 8” x 16”
  Actual size: 7 5/8” x 7 5/8” x 15 5/8”

CMU (cont)

- **The two most common types of CMU block are:**
  - **Heavy Weight Block: Cement, water and aggregates, such as sand, gravel and crushed limestone.**
  - **Light Weight Block: Cement, water and light weight aggregates, such as cinders, pumice, expanded shale, and vermiculite.**
    - **Light Weight units weigh about 30% less.**

(On SLIDE #24)

MODULAR PLANNING (CMU)

CMU walls are designed to make maximum use of full and half blocks using modular planning.

- **Wall lengths are modulated in increments of 8" and 16".**
- **Wall heights are modulated in increments of 8".**
- **Door and window openings should be placed where vertical joints occur as much as possible.**

DEMONSTRATION

CMU and Reinforcing Bar (REBAR) Construction

CMU REINFORCEMENT

- Vertical Reinforcement: Bars placed in the cores, and filled with concrete or mortar.

- Horizontal Reinforcement: Truss type reinforcement placed every second course to reduce shrinkage and settlement cracks.

- Pilasters: In walls 20’ or longer pilasters are placed every 10’ and filled with concrete.

QUESTIONS?

WOOD SPECIES & USES

- Materials made of wood come in a variety of species.
- The particular species of wood dictates its intended use in the construction of a structure.
- See Wood Species & Uses Chart.

LUMBER

- There are three distinct terms for wood in construction:
  - BOARDS: Less than 2" thick, and 1" to 16" wide.
  - DIMENSION LUMBER: 2" to 4 1/2" thick, and 1" to 16" wide.
  - TIMBER: Greater than 5" thick, and 5" wide.
- Standard lumber sizes were established to permit uniformity in design and ordering materials.

LUMBER GRADES

- **Lumber is graded for quality the two types of grades are:**
  - Select lumber has excellent appearance and good qualities for painting and finishes (stains).
    - **Grades A & B are best for natural finishes.**
    - **Grades C & D are best for painted surfaces**.
  - Common lumber is used for general construction.
    - **No. 1 is used for high quality construction (studs, roof trusses).**
    - **No. 2 is used for ordinary light construction (girders, joists, studs, and rafters).**
    - **No. 3 is used for low cost construction (blocking, concrete forms).**
    - **No. 4 is used when quality is of no concern (boxes, crates)**.

LUMBER CLASSIFICATION

- **Lumber is identified by its nominal size. Nominal sizes are larger the actual size.**

- **Lumber is classified according to its use and size, and falls into these categories:**

  - **Yard lumber**: Grades, sizes, and patterns that are intended ordinary construction and general building.

  - **Structural lumber**: Two or more inches in thickness and width for use where working stresses are required.

  - **Factory (Shop) lumber**: Used mainly for millwork, doors, windows, cabinets, etc...

TREATED LUMBER

- **Treated lumber: Used in structural areas prone to decay and/or insect damage such as sills attached to the tops of foundation walls, sole plates that come in contact with concrete slabs, and exterior stairs and decks.**

QUESTIONS?

DEMONSTRATION

Plywood Sheathing

PLYWOOD SHEATHING

- Plywood sheathing is used to cover the structures framework and provide additional lateral stability to the framing members.

- Plywood has a high degree of cross sectional strength, and is one of the most versatile building materials available.

- Plywood is normally used for forms, subflooring, exterior walls covering, roof coverings, etc..

PLYWOOD CLASSIFICATIONS

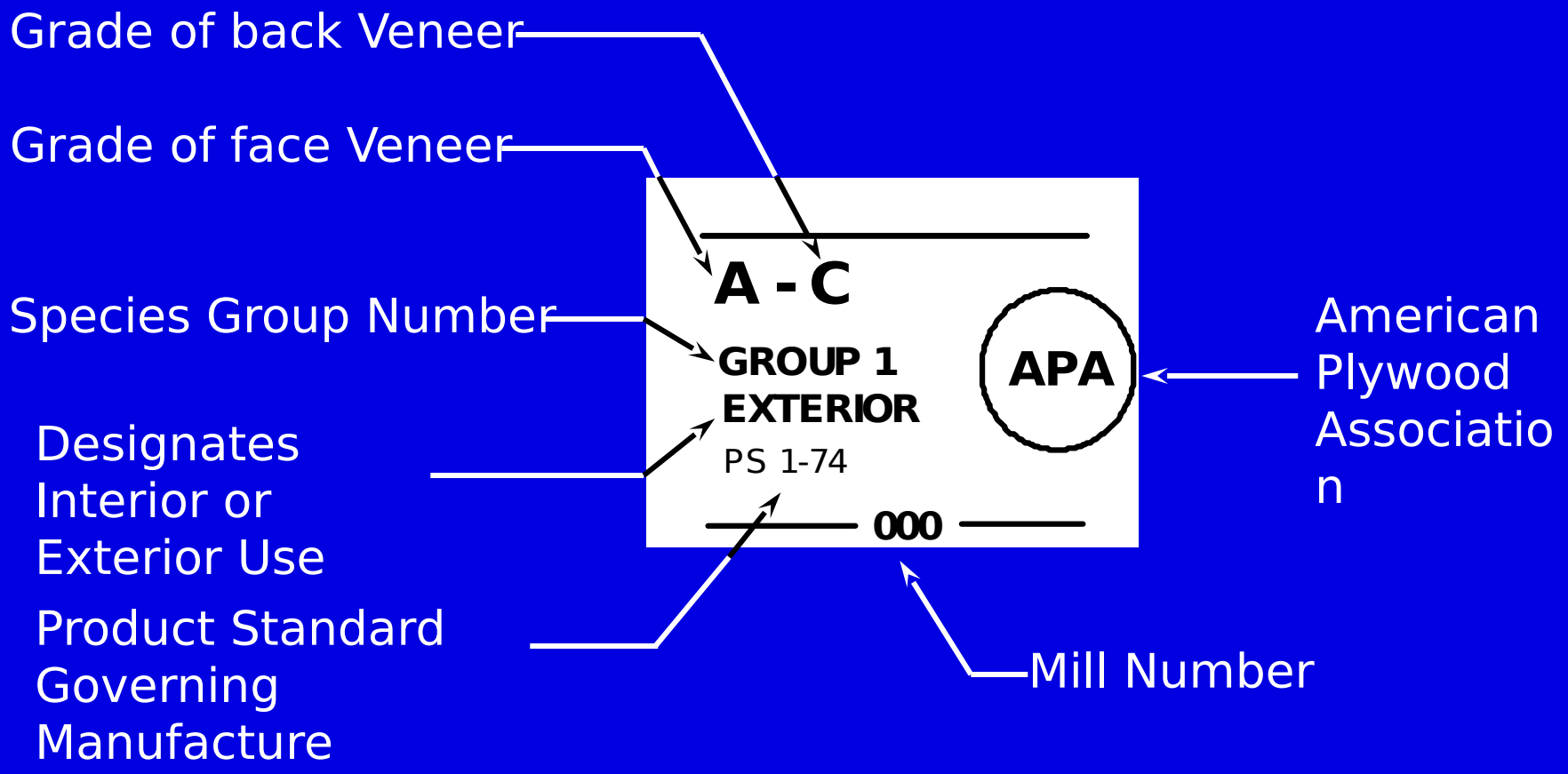
- **Plywood is classified according to its veneer grade. The plywood's grade helps identify its specific use. The two types of plywood are:**

  - Exterior plywood. Plywood made of high quality veneers and more durable adhesives to withstand exposure to the outside elements better.

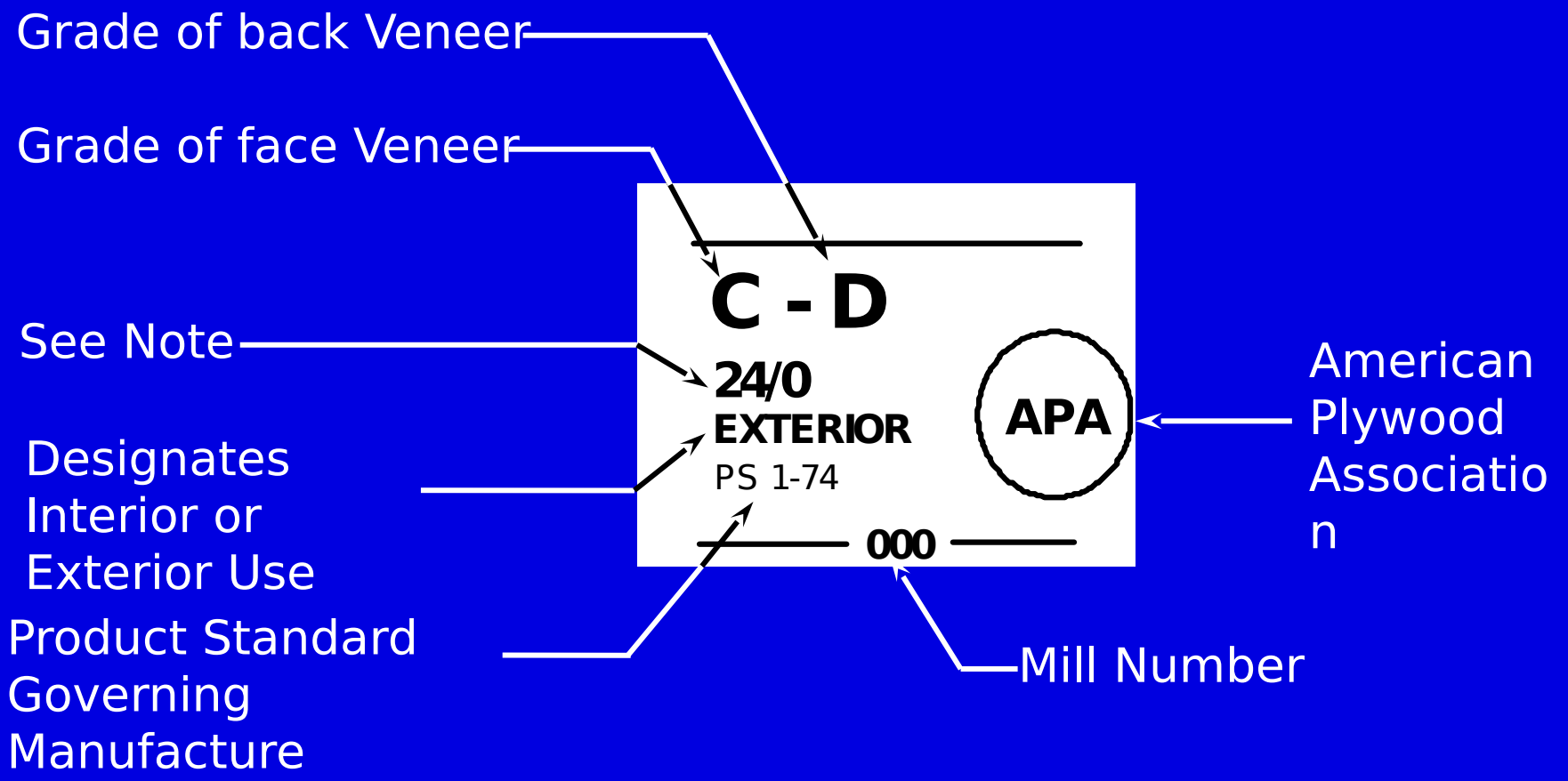
  - Interior plywood. Plywood intended mainly for interior coverings that are not subjected to prolong exposure to the elements. Does not do well when subjected to moisture.

  - see Plywood chart.

PLYWOOD STAMPS



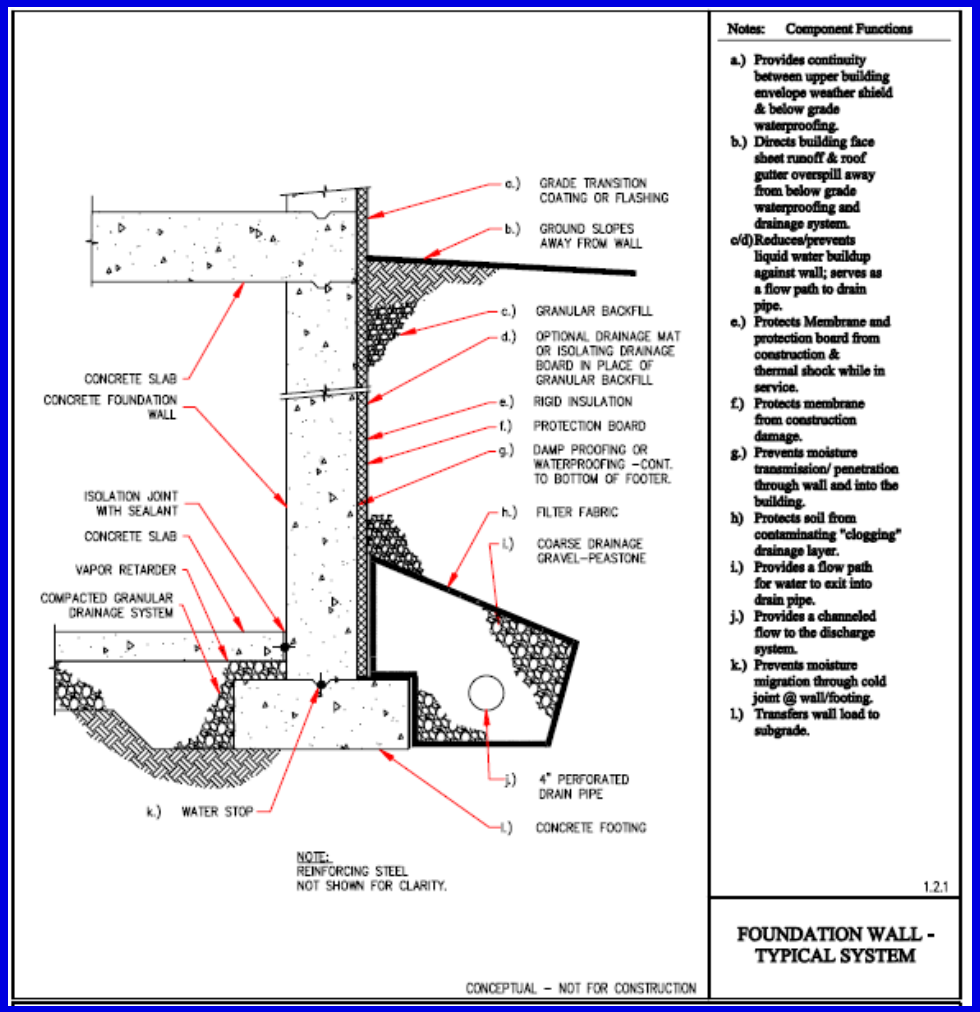
PLYWOOD STAMPS



Note: The index numbers give the maximum spacing in inches of supports. The number to the left of the slash is the maximum O.C. spacing of supports for roof decking. The number to the right of the slash is the maximum O.C. spacing of supports for subfloors. A "0" on the right indicates the panel should not be used for subflooring.

QUESTIONS?

FOUNDATIONS



FOUNDATION SYSTEMS

- The basic principles of foundation construction are the same regardless of the construction method.

- Every structure requires some type of foundation to support it. The foundation however, must be built on a soil that is stable enough to support the entire structure to include the foundation.

- An unstable soil will result in major structural damage as shifting occurs.

FOUNDATIONS

- The function of the foundation is to provide a level surface and uniform support for the structure itself.
- The foundation must be designed to support and distribute the load of the structure. The footings are the most critical element of the foundation.
- Footings support foundation walls, columns and distribute the weight of the entire structure over a large area of load bearing soil.
- The type of foundation you select for a structure depends on the type of soil it is to be built on and the size and weight of the structure that will be supported.

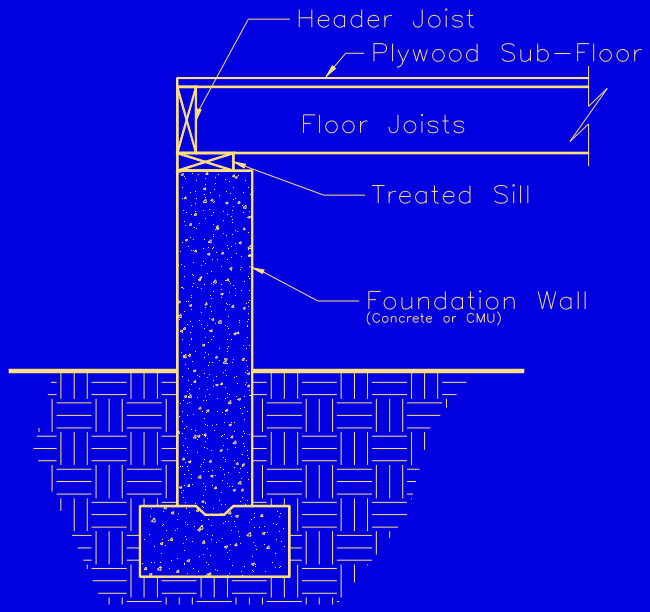
SOIL BEARING CAPACITIES

GENERAL SAFE SOIL BEARING CAPACITIES

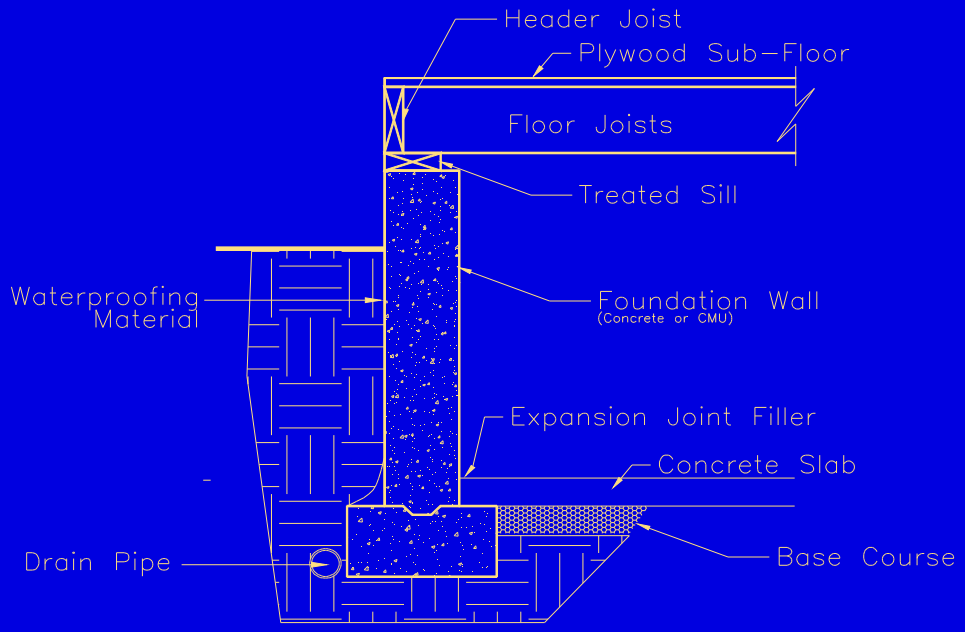
Soil Type	Safe Load Bearing Capacity (PSF)
Soft clay, loam, soft broken shale	2000 lb. per sq. ft.
Dry, firm sand, or clay	4000 lb. per sq. ft.
Compact, course sand	6000 lb. per sq. ft.
Course gravel, hard dry clay	8000 lb. per sq. ft.
Compact gravel, sand-gravel	20000 lb. per sq. ft.

“T” FOUNDATIONS

- **“T” foundations have a trench footing with a concrete wall or concrete block wall resting on top of it. This type of foundation is used if the structure requires a basement or crawl space.**



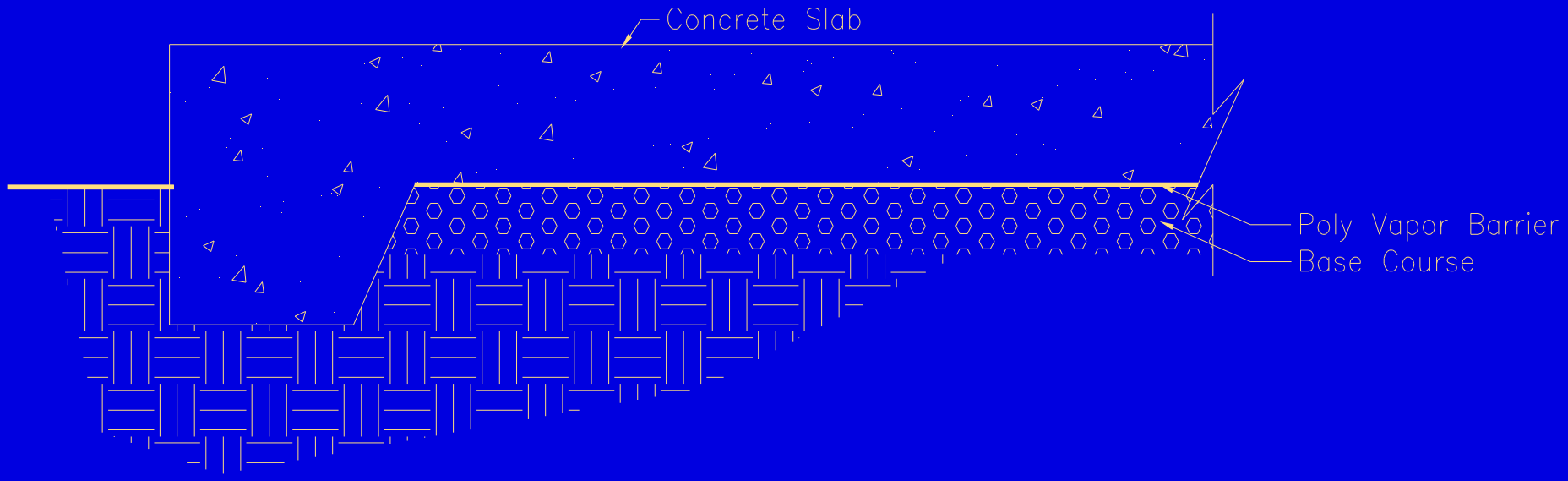
”T” Foundation
(Crawl Space)



”T” Foundation
(Basement)

SLAB FOUNDATIONS

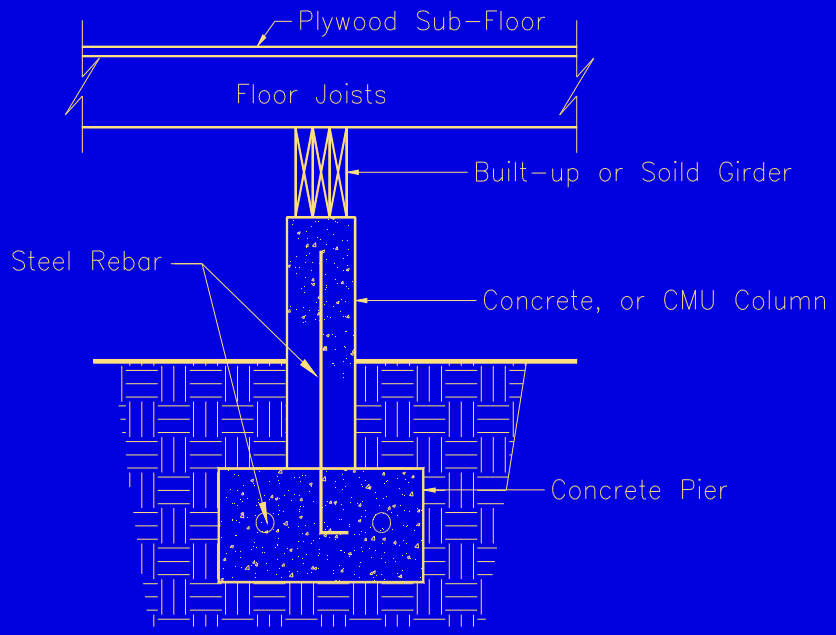
- **This type of foundation consists of a concrete slab which is poured directly on the ground, with trench footings poured at locations where additional support is required.**

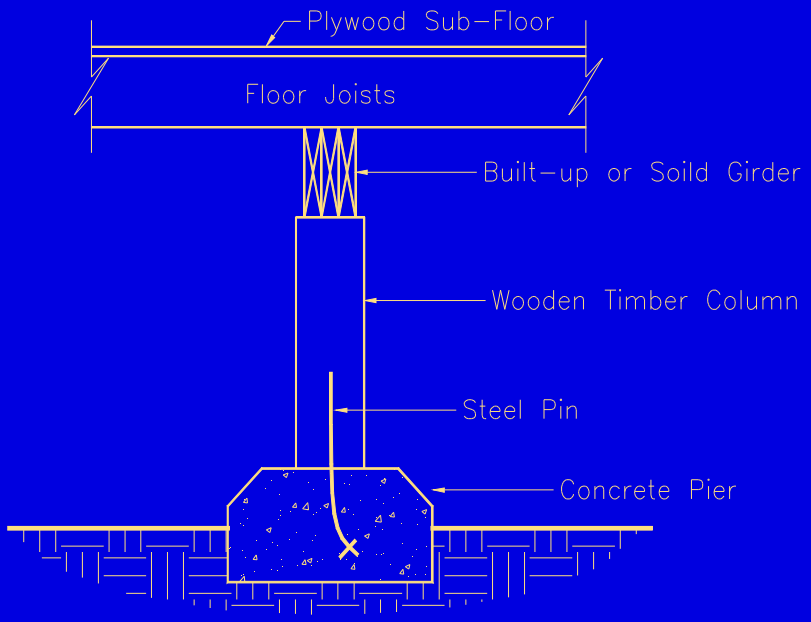


Slab Foundation

PIER-AND-COLUMN FOOTINGS

- **Pier-and-Column foundations consist of individual footers with a column placed on top of it. This type of foundation combination is used primarily for the support of girders and beams which support structural floor members.**





Pier-and-Column Foundation

QUESTIONS?

CONCRETE FOOTINGS

- The footing is the enlarged base of the foundation wall and must be massive enough to distribute the weight of the building to the ground below.

- Footings are placed a minimum of 12" below the frost line to reduce the effects of freezing and thawing which cause structural damage due to shifting.

CONCRETE FOOTINGS (cont)

- The soil that the footings rest on must be level, stable, and compact.
- The design of the footings must be able to support loads of the structure.
- Footings must have a minimum compressive strength of 2500 psi to effectively support the weight of the structure for its combined live and dead loads.

LOADS

- There are two types of loads that have an effect on any given structure. Determining these loads during design will enable you to determine sizes, and types of materials to be used.

  - Dead Loads. Refers to the weight of the structure itself and any stationary equipment fastened to it. These weights are represented as pounds per square foot.

  - Live Loads. These types of loads are not stationary and include people, wind, snow, rain, furniture. These weights are represented as pounds per square foot.

  - see Design Load Chart

FOOTING DESIGN

(Basic Rule)

- **The width of the footing is twice the width of the foundation wall it supports.**

- **The depth of the footing is equal to width of the foundation wall it supports.**

COMPUTATION METHOD

- **Step 1: Compute Rafter Length.**
  - (Span + OverHang length (both ends)) / 2 = **Run**
  - Run x Multiplying Factor = **Rafter Length**

Roof Slope		Mult. Factor
2:12	=	1.015
3:12	=	1.03
4:12	=	1.055
5:12	=	1.083
6:12	=	1.12

- **Step 2: Compute Design Loads**
  - Total live and dead loads for roof x rafter lengths.
  - Total live and dead loads for ceiling x half span of ceiling.
  - Total dead load for exterior wall x wall height.
  - Total live and dead loads for floor x half span of floor.
  - Total dead load for foundation wall x wall height.
  - Total dead load for footings x trial footing surface area (1.33’).
  - Add all totals to compute "total area of footing per

Step 3: Determine Design Footing Width

- Total area of footing per lineal foot of wall = Req'd footing area.

  Soil bearing capacity

- Required footing area x 12” = Design footing width.

- Note: Computed design footing width is rounded up to nearest whole number. If the computed value is equal to or less than the trial footing width, then the trial footing width is adequate to support the loads of the structure. If not, then the computed design footing width must be used to support the structure.

DEMONSTRATION

FOOTING COMPUTATION

- **Example: The structure we have been tasked to design is a classroom for TA244.**
  - **The structure measures 28' x 40' with 8' high walls.**
  - **The new structure will require a 4' high crawl space for access to plumbing piping if the need arises.**
  - **The roof will be a gable end type and have a 5:12 slope, with 18" overhang on all sides.**
  - **The soil type that this structure is to be built on is comprised of a soft clay with a load bearing capacity of 2000 lb. psf..**

PRACTICAL EXERCISES

PGS SO-XX

30 MINUTES

FOOTING REINFORCEMENT

- Steel reinforcement is added to the footings to prevent the concrete from cracking and add additional support. The steel reinforcement bars are normally 3 or 4 lengths of 3/8" or 1/2" bars that run parallel to the length of the footings. These reinforcement bars must be placed 1 1/2" below the top of the footings to be effective.

- When a concrete wall is to be poured on top of the footing, a key-way must be formed in the top of the footing, and steel rebar must extend vertically into the wall form, so footings will interlock with the concrete wall and provide a stronger bond between footing and wall.

- The size of the footing depends on the load-bearing capacity of the soil, and the load it will support. An ordinary column footing that is 24" x 24" x 12" will support 16,000 lbs if the soil bearing capacity is 4000 lbs per square feet.

FOOTING REINFORCEMENT

- A steel pin is inserted into the footing during the pour, and extends a minimum of 14" through the top if a wooden column is going to be used. After the concrete has cured, the wooden column is seated onto the steel pin so it will be interlocked with the footing.

- If concrete blocks are to be used as a pier, then rebar must extend from the footing into the cores of the concrete block for reinforcement. The cores of the concrete blocks are filled with masonry cement for additional stability, and the base course of block is bonded to the footing with masonry cement.

- In the case where poured concrete will be used as a pier, steel rebar must be used in the column to prevent bending. Rebar extends vertically from the footing into the column form, and the rebar is tied together with tie wire to prevent the rebar from bulging during the pour.

- The maximum spacing of pier-and-column footings must not exceed 8' o.c.. This spacing will provide more than sufficient support for built-up girders that are to be supported.

QUESTIONS?

FOUNDATION WALLS

- The function of the foundation wall is to support the superstructure of the building above the ground line, and to transmit the weight of the structure to the footing.
- Foundation walls can be constructed from concrete, concrete block, brick, or stone.
- Poured concrete walls are considered more reliable, but require more labor to construct forms, and also requires time for the concrete to set and harden.
- Concrete walls should not be less than 8" thick. Anything less than that will cause the walls to fail in shear or buckle due to earth pressures.
- Foundation walls, supporting wood frame construction, must extend a minimum of 8" above the finish grade to prevent decay of wooden sills that are fastened to them.

DEMONSTRATION

Wooden Sill Construction

FOUNDATION WALLS
WOODEN SILLS

- When fastening wooden sills to the top of concrete foundation walls, anchor bolts are initially set at a distance of 6" in from each outside corner of the walls.

- Thereafter, anchor bolts are spaced at every 6' to 8' o.c.. There must be at least 2 anchor bolts in each wooden sill.

- The hole that is drilled in the wooden sills must be 1/16" larger than the diameter of the bolt. The diameter of the anchor bolts, used in light frame construction, must not be less than 1/2" in diameter.

- Once anchor bolts have been set it is important that the alignment is not disturbed. These types of anchors allow the structural floor to be securely fastened to the foundation walls.

QUESTIONS?

CONCRETE SLABS

- Ground-supported slabs rest directly on a base course (slab bed) consisting of undisturbed soil, compacted fill, or base course material.

- Ground-supported slabs are designated as types I, II, III, or IV.

TYPE I CONCRETE SLAB

- 4" in nominal thickness
- Generally un-reinforced
- Rectangular or square in shape
- No perimeter dimension greater than 32 feet
- Contraction joints used every 15' to 20'

TYPE II CONCRETE SLAB

- 4" in nominal thickness
- Reinforced with steel
- Rectangular or square in shape
- No perimeter dimension greater than 75 feet
- Dimensions up to 45' require 6x6 10 ga. Wire
- Dimensions 45' to 60' require 6x6 8 ga. Wire
- Dimensions 60' to 75' require 6x6 6 ga. Wire
- Expansion joints used every 15' to 20'

TYPE III CONCRETE SLAB

- 4" to 6" in nominal thickness
- Reinforced with steel
- Built over problem soils

TYPE IV CONCRETE SLAB

- Greater than 4" in nominal thickness
- Does not depend on soil for support
- Independently supported, rest on foundation walls
- Structurally reinforced
- Must be designed by a structural engineer

CONCRETE SLAB CLASSIFICATIONS

(Class 1 – Class 6)

CLASS 1 CONCRETE SLAB

- Light foot traffic
- Used in light frame construction
- Minimum of 4" thick
- 28 day compressive strength of 3,500 psi

CLASS 2 CONCRETE SLAB

- Medium foot traffic
- Used in offices and class rooms
- Minimum of 4" thick
- 28 day compressive strength of 3,500 psi

CLASS 3 CONCRETE SLAB

- Pneumatic wheeled traffic
- Used in drives, sidewalks, and garages
- Minimum of 4" thick
- 28 day compressive strength of 3,500 psi

CLASS 4 CONCRETE SLAB

- Heavy foot and pneumatic wheeled traffic
- Used in industrial structures
- Minimum of 6" thick
- 28 day compressive strength of 4,000 psi

CLASS 5 CONCRETE SLAB

- Heavy foot and abrasive wheeled traffic
- Used in medium industrial structures
- Minimum of 6" to 8" thick
- 28 day compressive strength of 4,500 psi

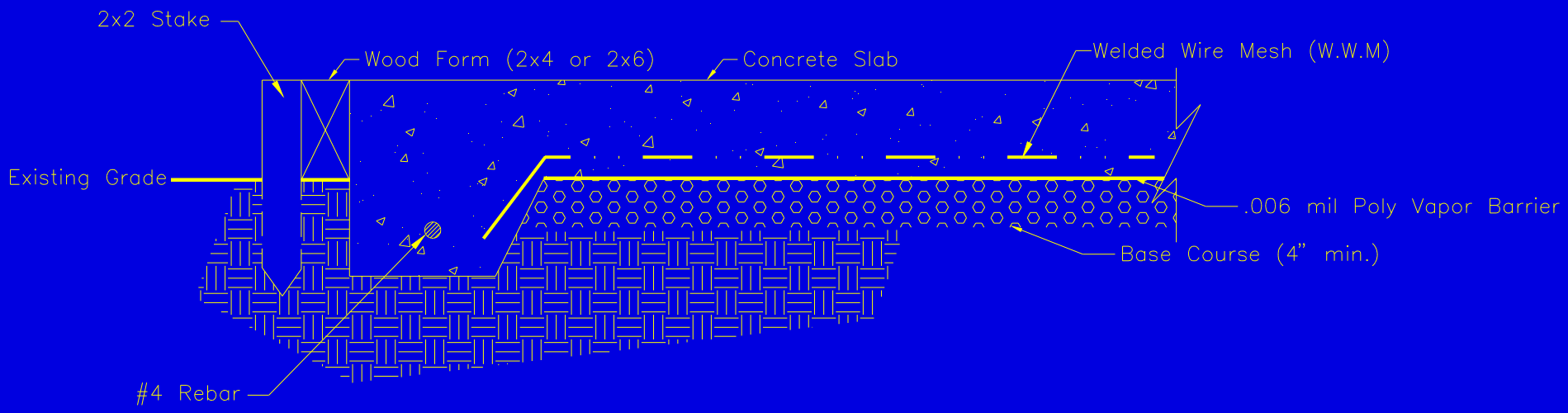
CLASS 6 CONCRETE SLAB

- Heavy foot and steel tire traffic
- Used in heavy industrial structures
- Over 8" thick
- 28 day compressive strength of 5,000 to 8,000 psi

CONCRETE SLAB EXCAVATION

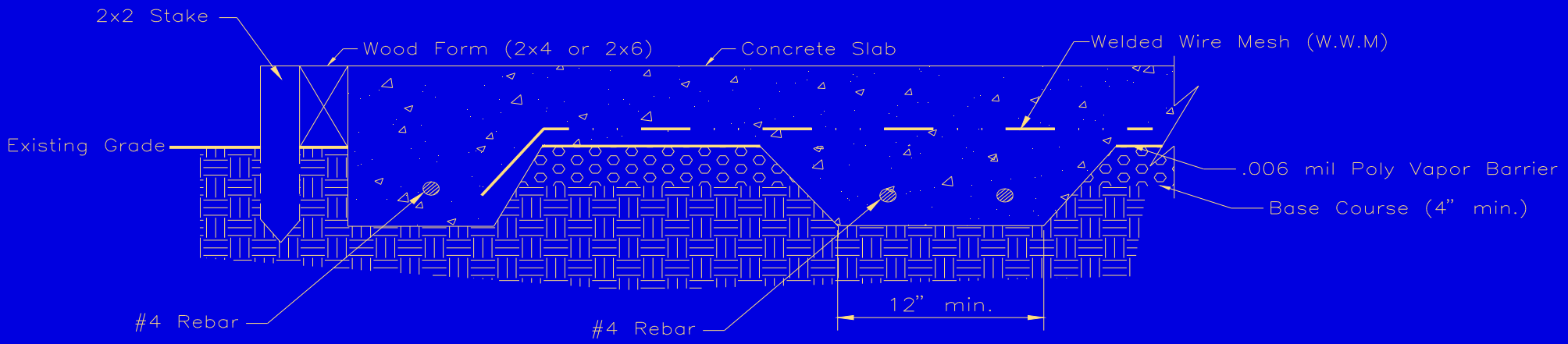
- The excavation for the slab foundation is made for the footings only.
- The depth of the footings is dictated by the depth required to ensure the bottom of the footing is below the frost line.
- If bearing walls are erected on the slab, the width of the footing base is twice the width of the wall itself.

SLAB EXCAVATION



SLAB-ON-GRADE ELEMENTS

SLAB w/BEARING INTERIOR WALL



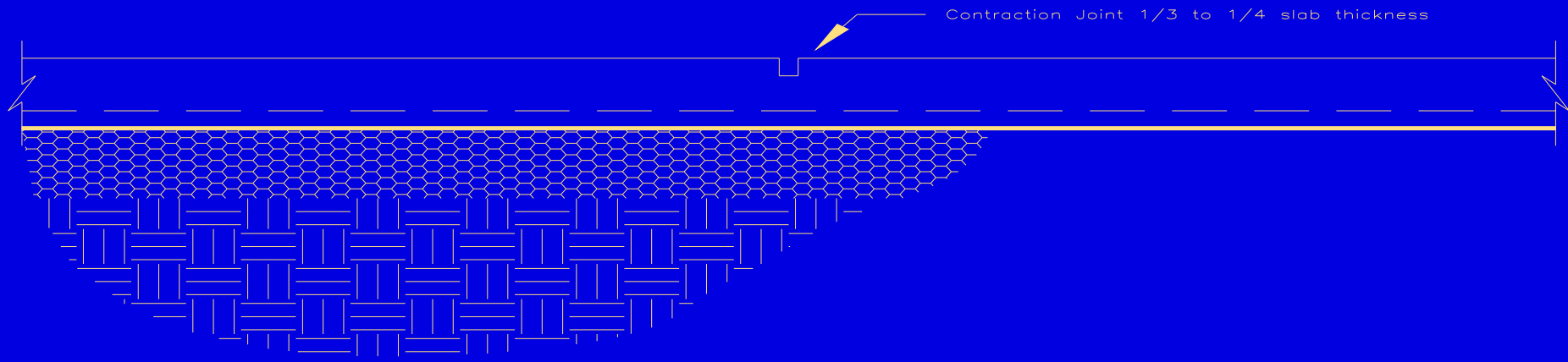
SLAB—ON—GRADE w/ INTERIOR BEARING PARTITION

CONSTRUCTION JOINTS

- Construction joints are divisions made between concrete work that is placed at intervals, and spaced widely enough to allow partial hardening of the concrete.
- These construction joints are found in large concrete slab work.
- Foundation walls are bonded to the footings with a construction joint called a key-way.

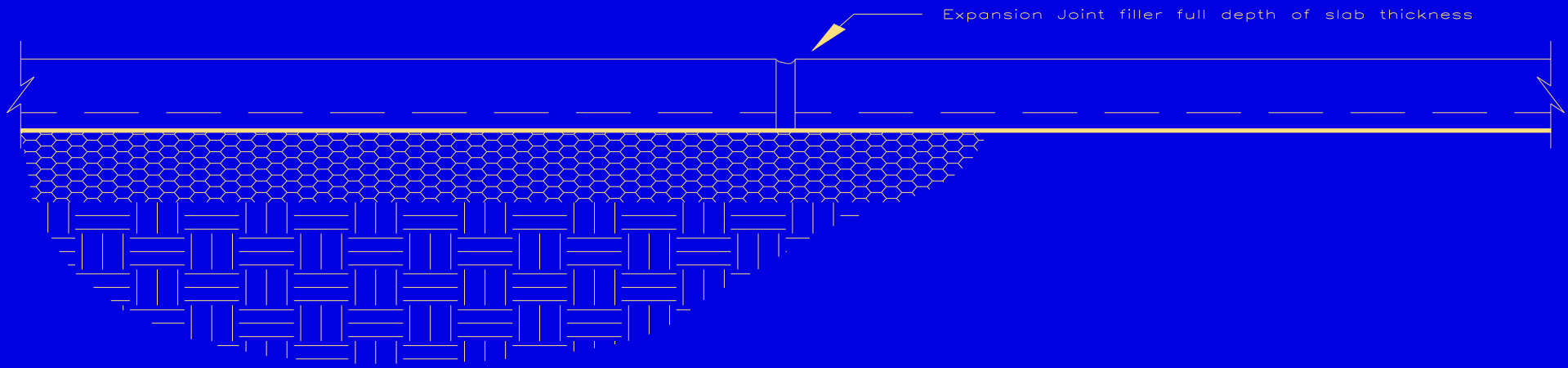
CONTRACTION JOINTS

- Contraction joints are used to control cracking which is caused by temperature changes. These joints are placed at intervals of 15 to 25 feet.



EXPANSION JOINTS

- These types of joints are placed between section pours of large concrete slab work. Expansion joints are placed every 20 feet, and are made of bituminous material or a mastic filler.



QUESTIONS?

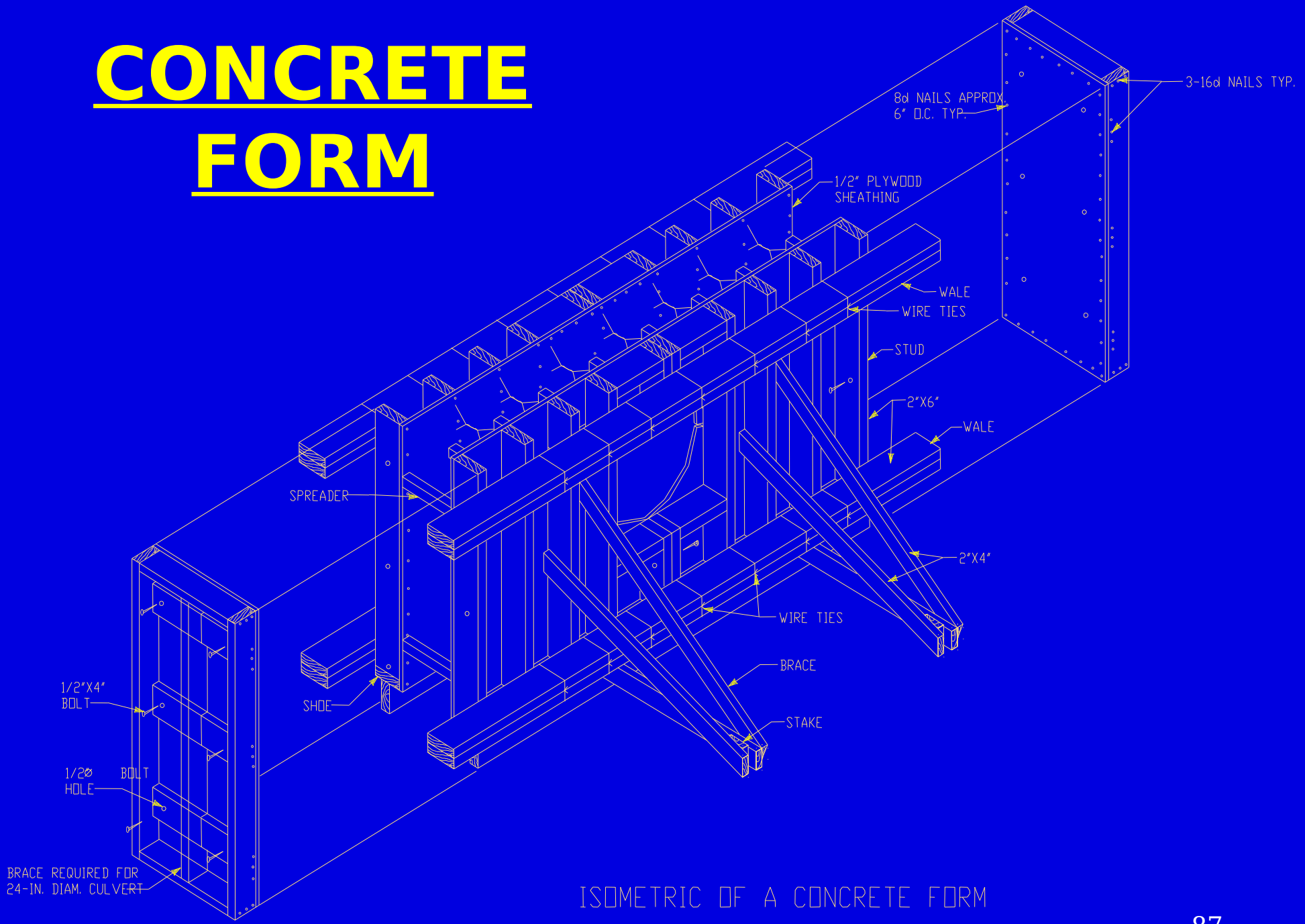
CONCRETE FORMS

- Concrete forms play a major role in concrete construction.
- Forms give concrete its shape and hold it in place until it hardens.
- Concrete will have a "honeycomb" effect if the designed forms are not tight when constructed.

CONCRETE FORMS COMPONENTS

- **Sheathing forms the vertical surface of the concrete wall.**
- **Studs reinforce the sheathing, spacing starts as small as 6” up to 4’.**
- **Wales are used to reinforce the studs and ensure the form work stays aligned.**
- **Braces are used to help stabilize the form work from shifting.**
- **Spreaders are small pieces of wood placed between sheathing panels to maintain correct wall thickness.**
- **Tie Wire secure the forms against lateral pressure of the fresh concrete. Tie rods or snap ties are also used instead of tie wires because they are easier to**

CONCRETE FORM



ISOMETRIC OF A CONCRETE FORM

QUESTIONS?

DEMONSTRATION

Framing Construction

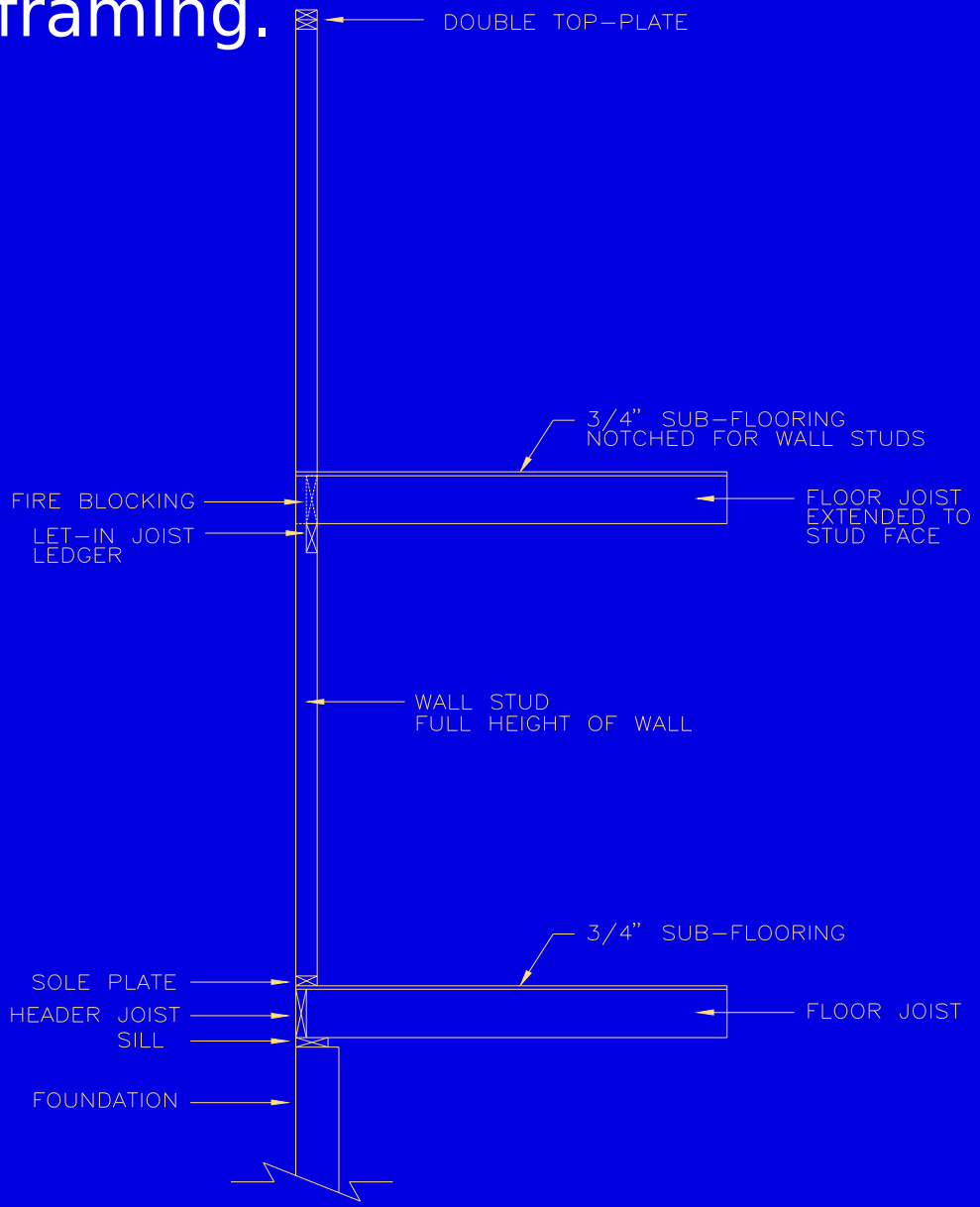
FRAMING CATEGORIES

The basic principles of framing have not changed over the last couple of centuries. They are broken into 3 major categories.

- Floor Framing
- Wall Framing
- Roof Framing

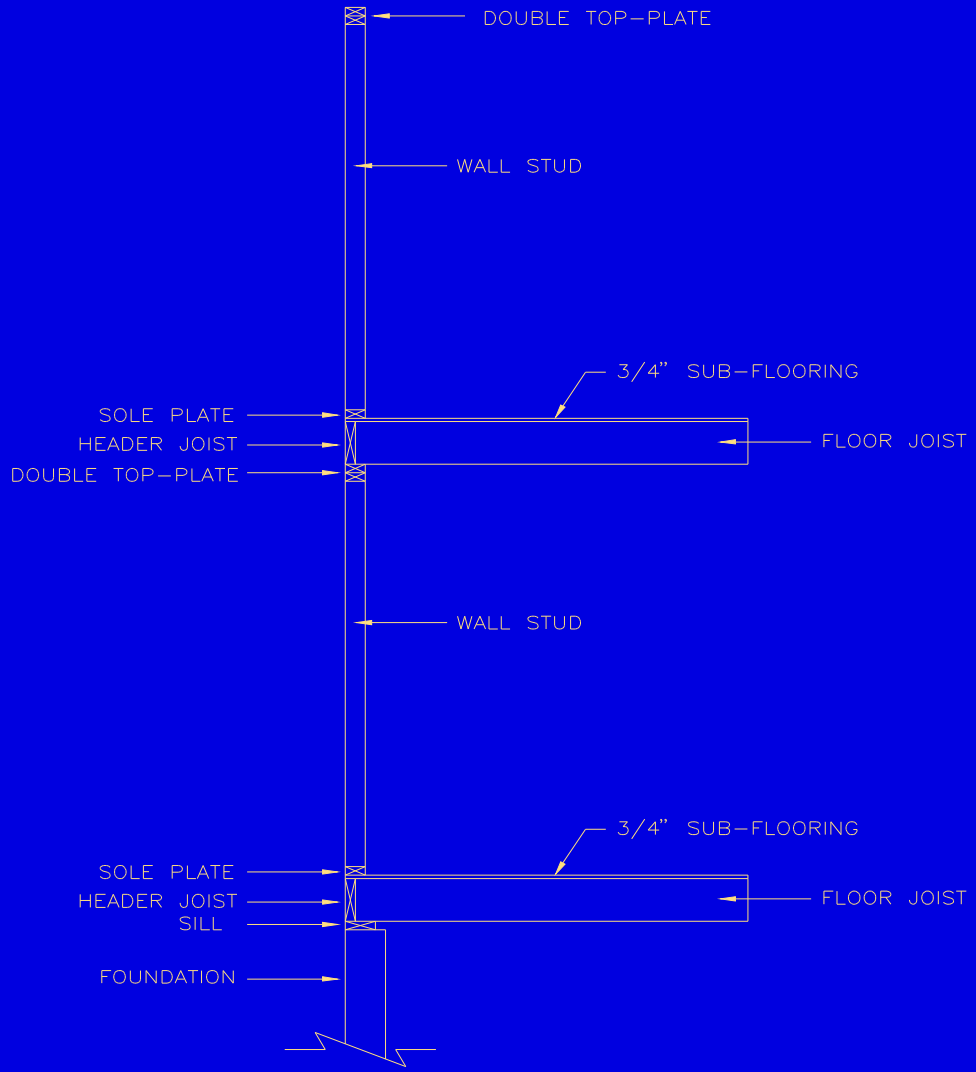
BALLOON FRAMING

- Method used for older multistory structures. Studs run full length from sill to rafter, and is less rigid than Western framing.



PLATFORM FRAMING

- Method used most extensively in light military construction of temporary facilities. Primary method used to construct one-story structures. Allows uniform settling of walls.



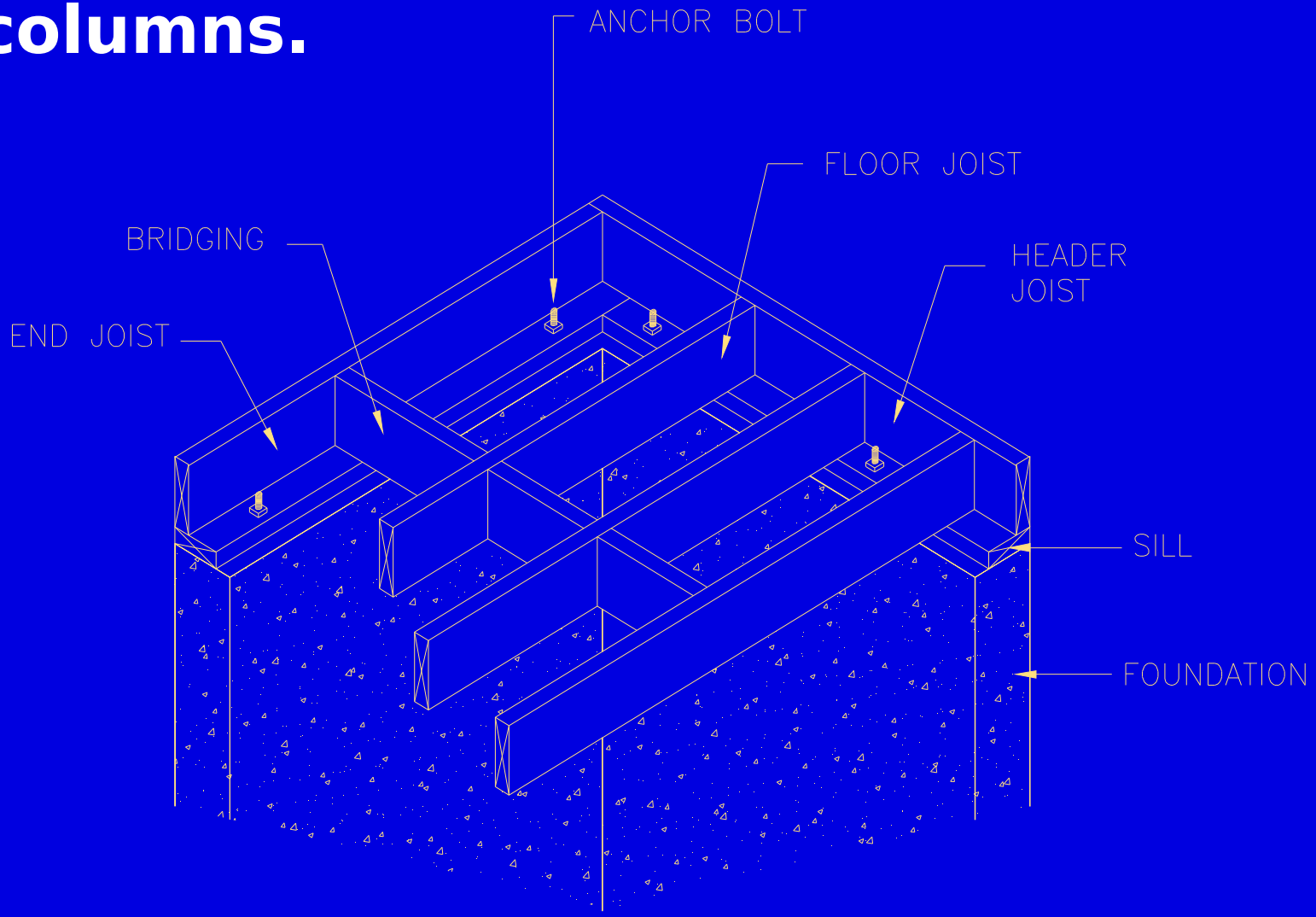
STRUCTURE ACTIONS

- The stability of the structure depends on the strength of the framing materials that are used and the method of connecting each of the framing members

- Structures must be designed so framing materials will have the strength to overcome four types of actions.
  - Tension (stretching)
  - Compression (compaction)
  - Shear (cutting)
  - Torsion (twisting)

FLOOR FRAMING

Floor framing is supported by the foundation walls and girders with columns.



FLOOR FRAMING

The box sill is the most commonly used sill system in platform framing and is the first part of framing to be put in place.

- Sills resting on concrete foundations are made of treated lumber to resist decay and insect damage.
- Sills are attached to concrete foundations using 1/2" dia. anchor bolts spaced at 6' centers.
- Structural floor framing members are supported with built-up girders when the width of the building exceeds 15 feet. Column supports must not exceed 8' o.c..

MAXIMUM WOODEN POST LOADS

Nominal size, inches	3 x 3	4 x 4	4 x 6	6 x 6	6 x 8	8 x 8
Area in square inches	9.51	13.14	20.39	30.25	41.25	56.25
HEIGHT OF COLUMN						
4 FEET	8,720	12,920	19,850	30,250	41,250	56,250
5 FEET	7,430	12,400	19,200	30,050	41,000	56,250
6 FEET	5,630	11,600	17,950	29,500	40,260	56,250
6 FEET 6 INCHES	4,750	10,880	16,850	29,300	39,950	56,000
7 FEET	4,130	10,040	15,550	29,000	39,600	55,650
7 FEET 6 INCHES		9,300	14,400	28,800	39,000	55,300
8 FEET		8,350	12,950	28,150	38,300	55,000
9 FEET		6,500	10,100	26,850	36,600	54,340
10 FEET			24,670	33,600	53,400	
11 FEET			22,280	30,380	52,100	
12 FEET			19,630	26,800	50,400	

SAFE GIRDER LOADS

- Girders carry a large portion of the building weight, and should be large enough to support an ordinary load.
- Safe loads in pounds for spans from 6 to 10 feet

GIRDER SIZE	6 ft	7 ft	8 ft	9 ft	10 ft
6 x 8 SOLID	8,306	7,118	6,220	5,539	4,583
6 x 8 BUILT-UP	7,359	6,306	5,511	4,908	4,062
6 x 10 SOLID	11,357	10,804	9,980	8,887	7,997
6 x 10 BUILT-UP	10,068	9,576	8,844	7,878	7,086
8 x 8 SOLID	11,326	9,706	8,482	7,553	6,250
8 x 8 BUILT-UP	9,812	8,408	7,348	6,544	5,416

FLOOR JOISTS

Floor joists are the major structural members of the floor system. For spans greater than 10 feet, 2 x 8, 2 x 10, or 2 x 12 lumber is used.

- **To determine the maximum distance a joist can span, and safely support a live load of 40 lb per sqft use the following formula:**

1.5 x the width of the joist = max length @ 16" o.c.

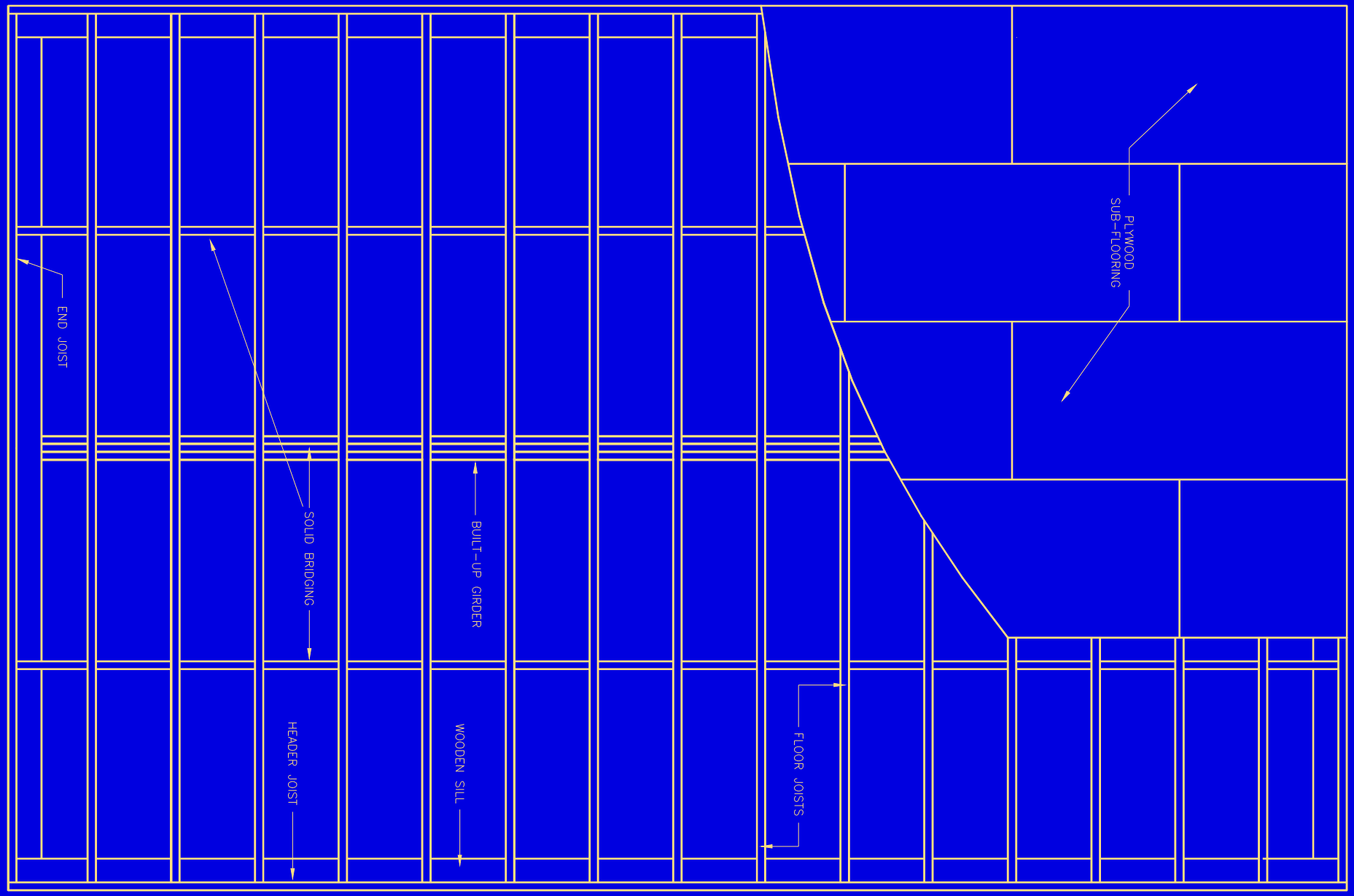
FLOOR FRAMING

- Bridging stiffens the floor joists and prevents them from swaying. One line of bridging is required between floor joists when the joists are no more than 8' long, and two lines are required for joists 16 feet long.

- Plywood sheathing, 5/8" or 3/4”, is used as sub-flooring to tie all structural floor members together and provide a smooth surface for finish floors. The joist spacing should not exceed 16" o.c. when a finish floor will be laid parallel to the joists.

- Plywood sub-flooring must be laid perpendicular to the floor joists to prevent low spots (sagging) in the floor.

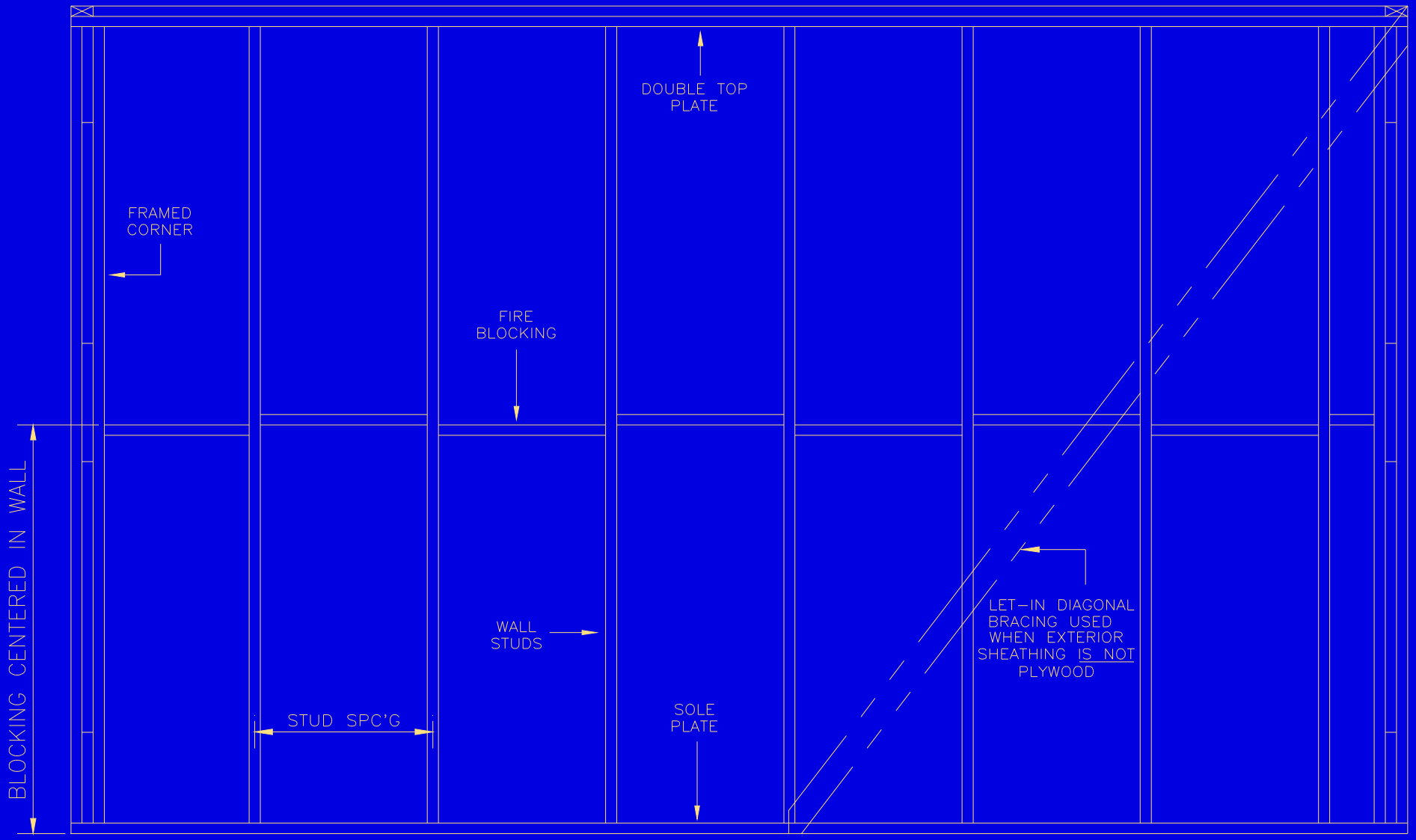
FLOOR FRAMING



WALL FRAMING

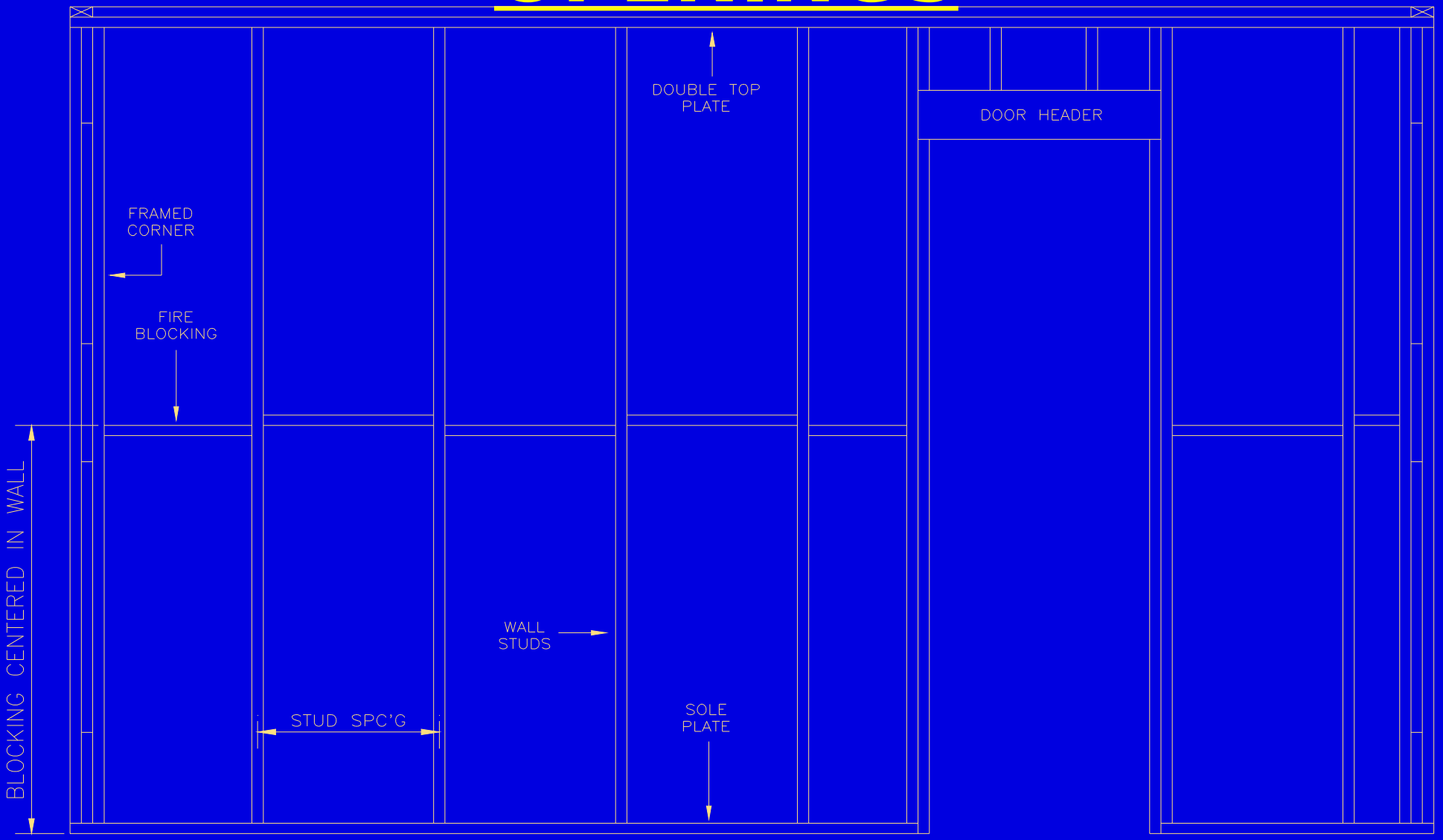
- Studs are the vertical framing members for exterior and interior walls. Sole plates and top plates are the nailing bases for the studs/
- All door and window openings must have double studs at the jambs.
- Let-in bracing is required at exterior corners to counteract wind pressures and lateral movements, and to stiffen the framework.
- Fire blocking is nailed between the studs half way up the walls to reduce air flow to slow the spread of fires.

TYPICAL WALL FRAME



TYPICAL FRAMED WALL

TYPICAL WALL FRAME w/ OPENINGS



TYPICAL FRAMED WALL w/ OPENINGS

DEMONSTRATION

Partition Wall

INTERIOR PARTITIONS

There are two types of interior partition walls:

- Bearing partition walls support ceiling joists.
- Nonbearing partition walls support themselves.
- Interior partition walls are framed the same way as exterior walls, but without diagonal bracing.

ROOF FRAMING

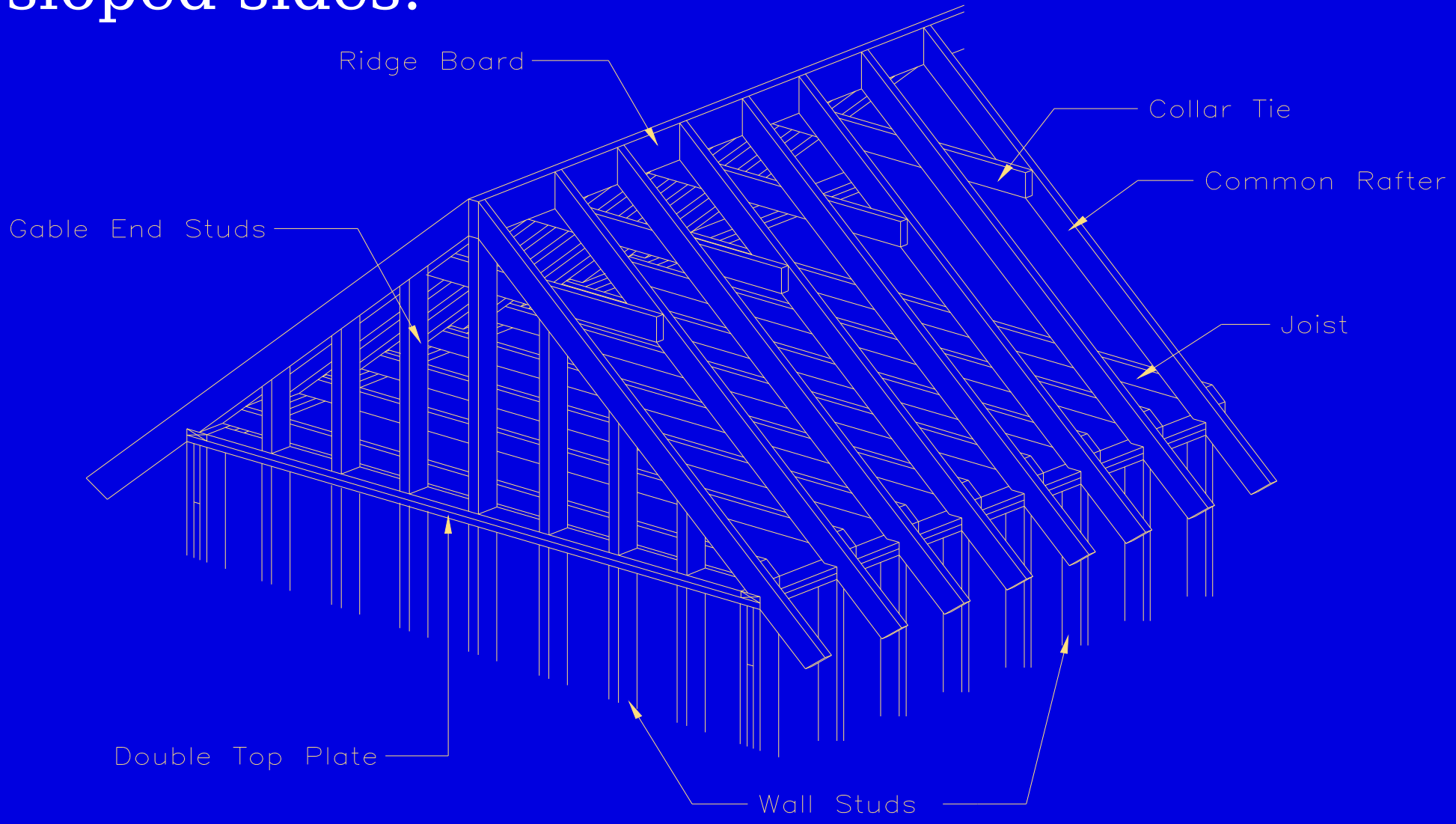
Roof systems must be sloped to some degree to allow water to run off.

Roof systems are made of one or a combination of three major roof types:

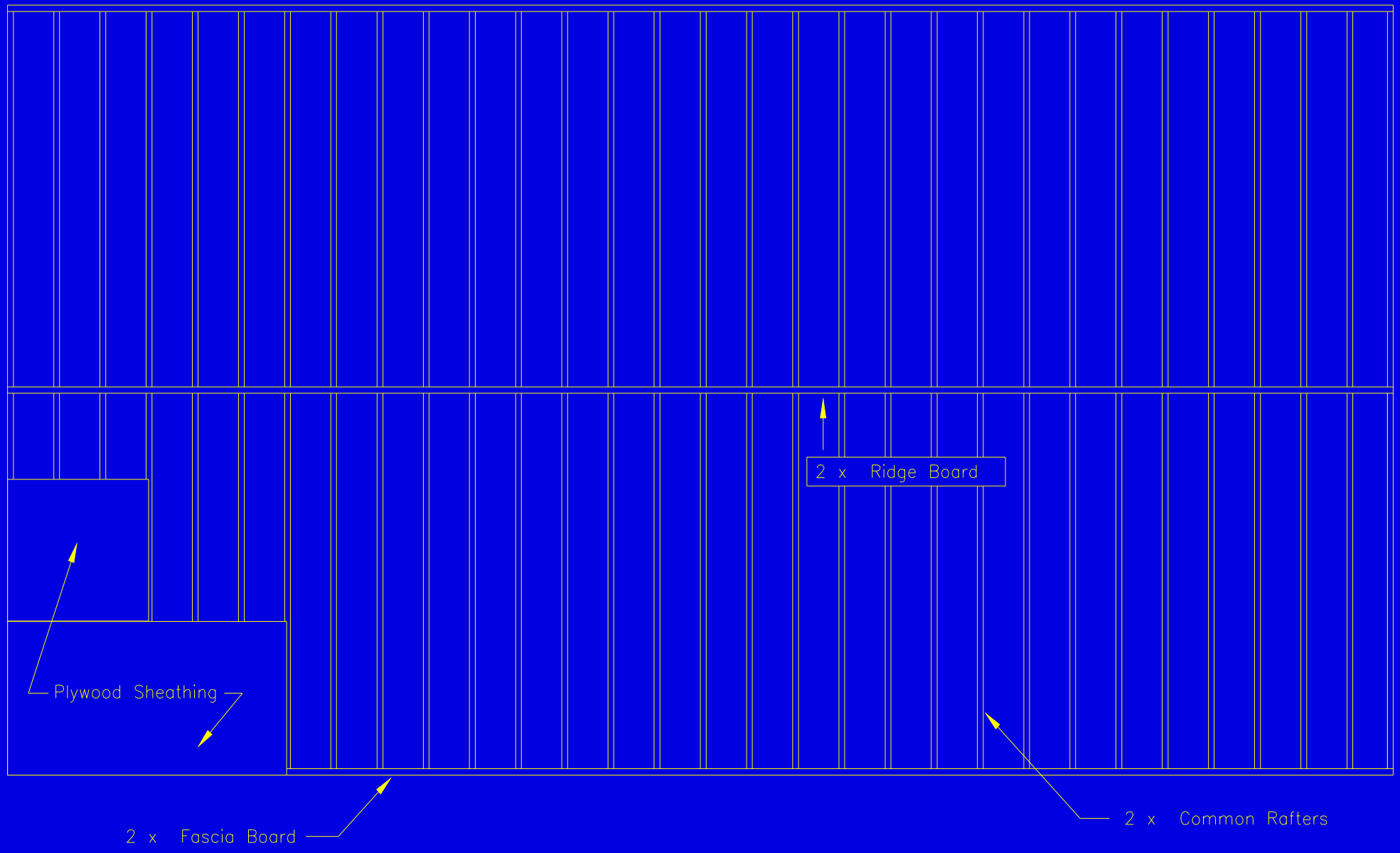
1. **Gable end roof**
2. **Hip roof**
3. **Shed roof**

GABLE END ROOF

Gabel end roofs have vertical ends with sloped sides.



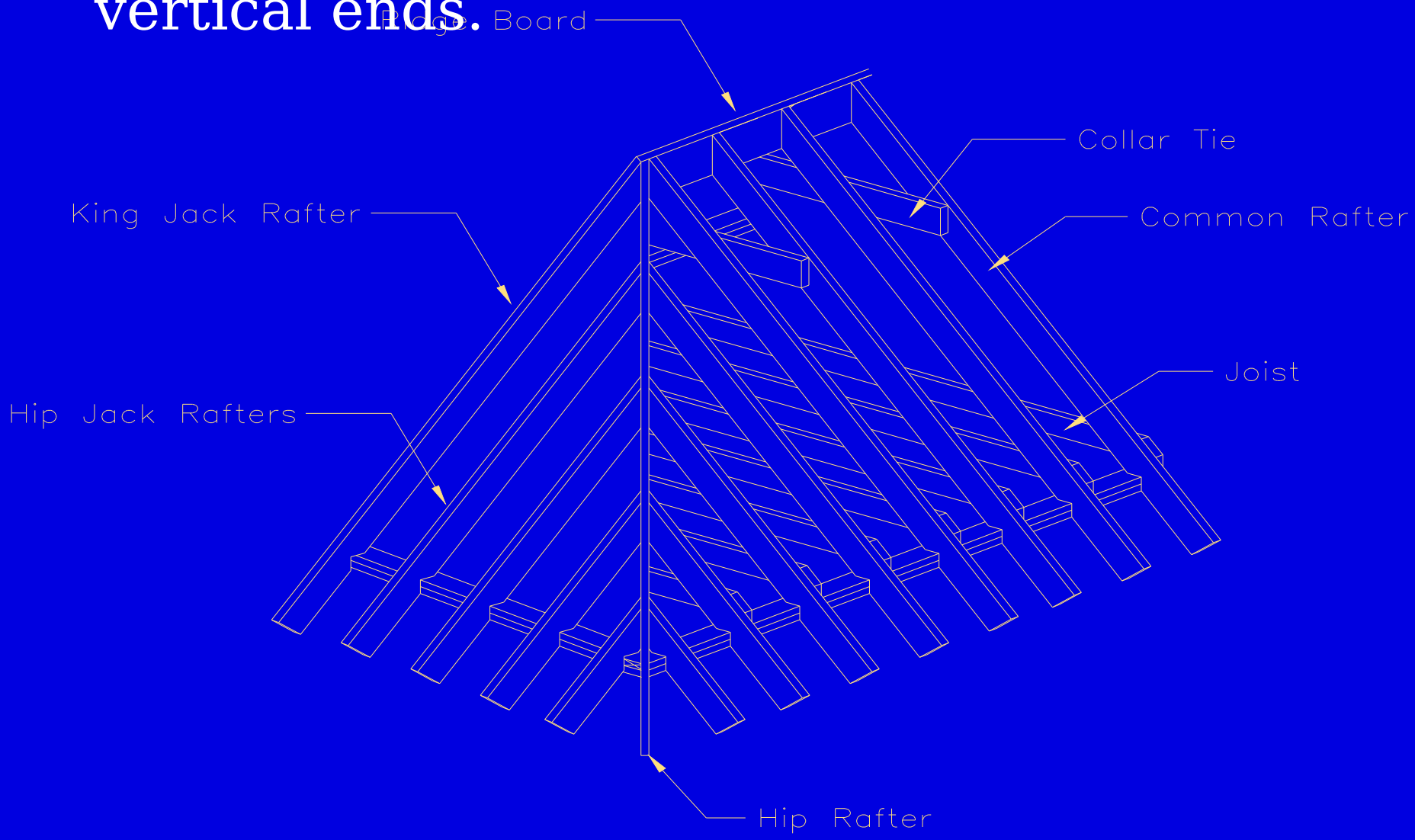
GABLE FRAMING PLAN



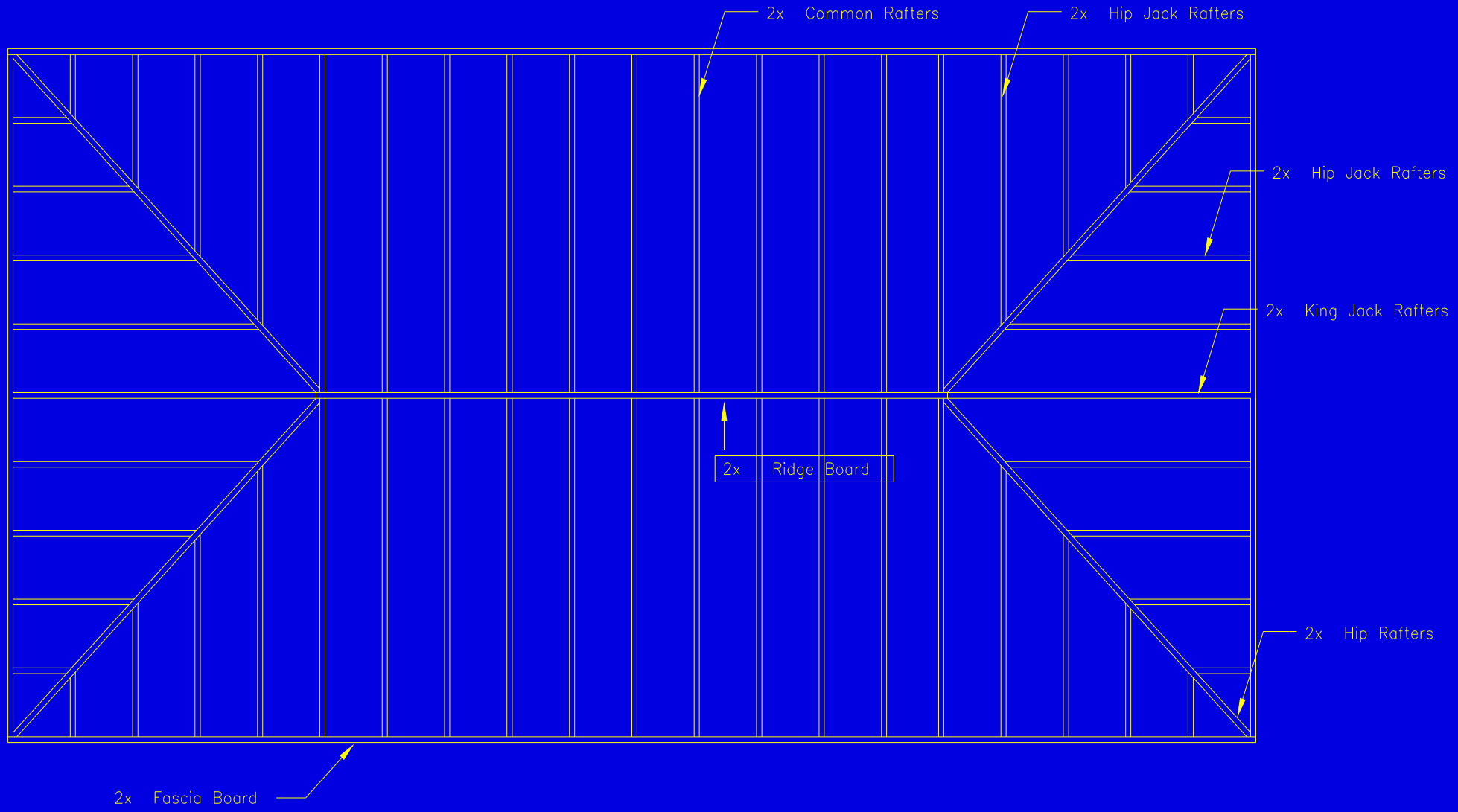
GABLE ROOF FRAMING PLAN

HIP ROOF

Hip roofs have all sides sloped with no vertical ends.



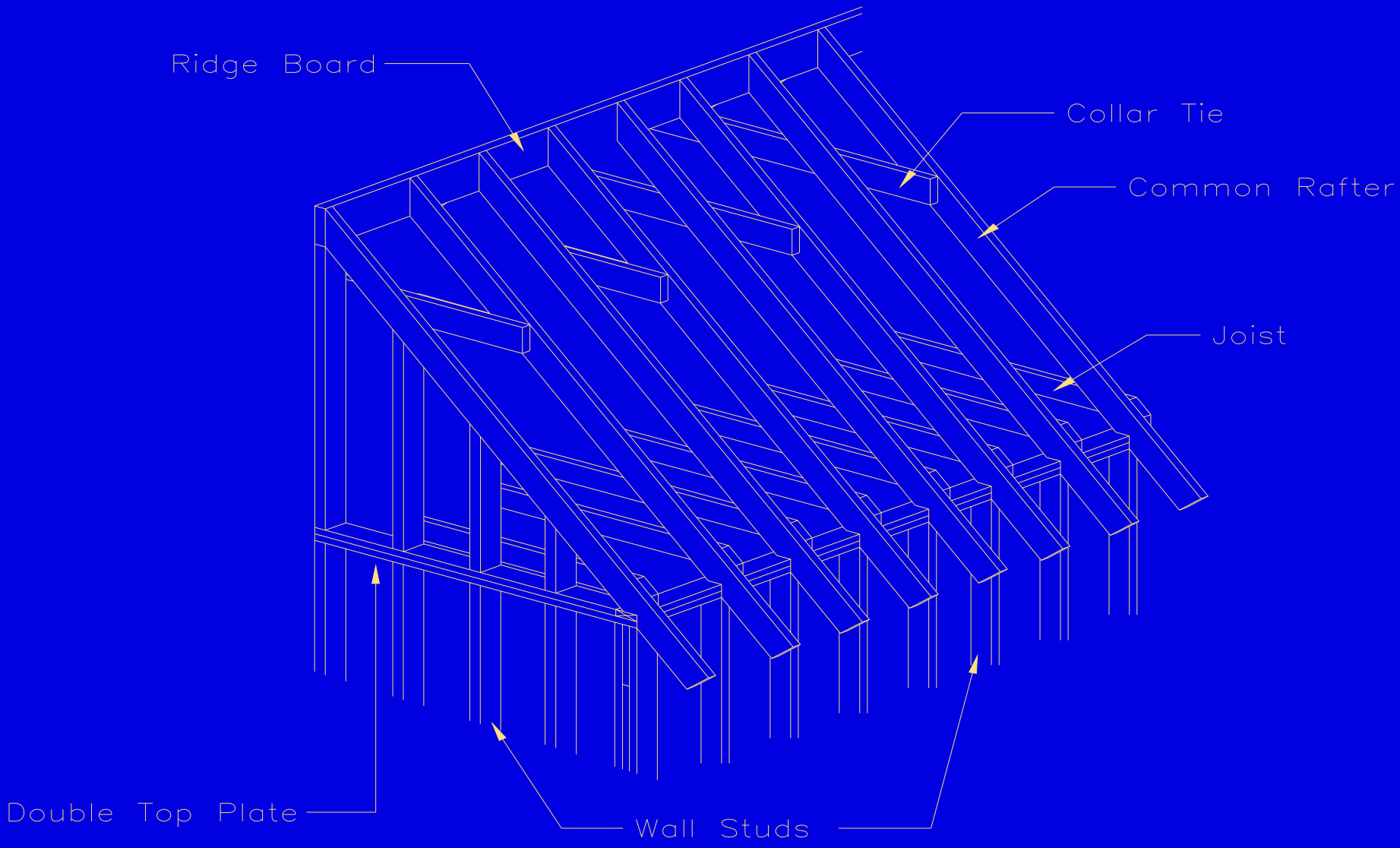
HIP ROOF FRAMING PLAN



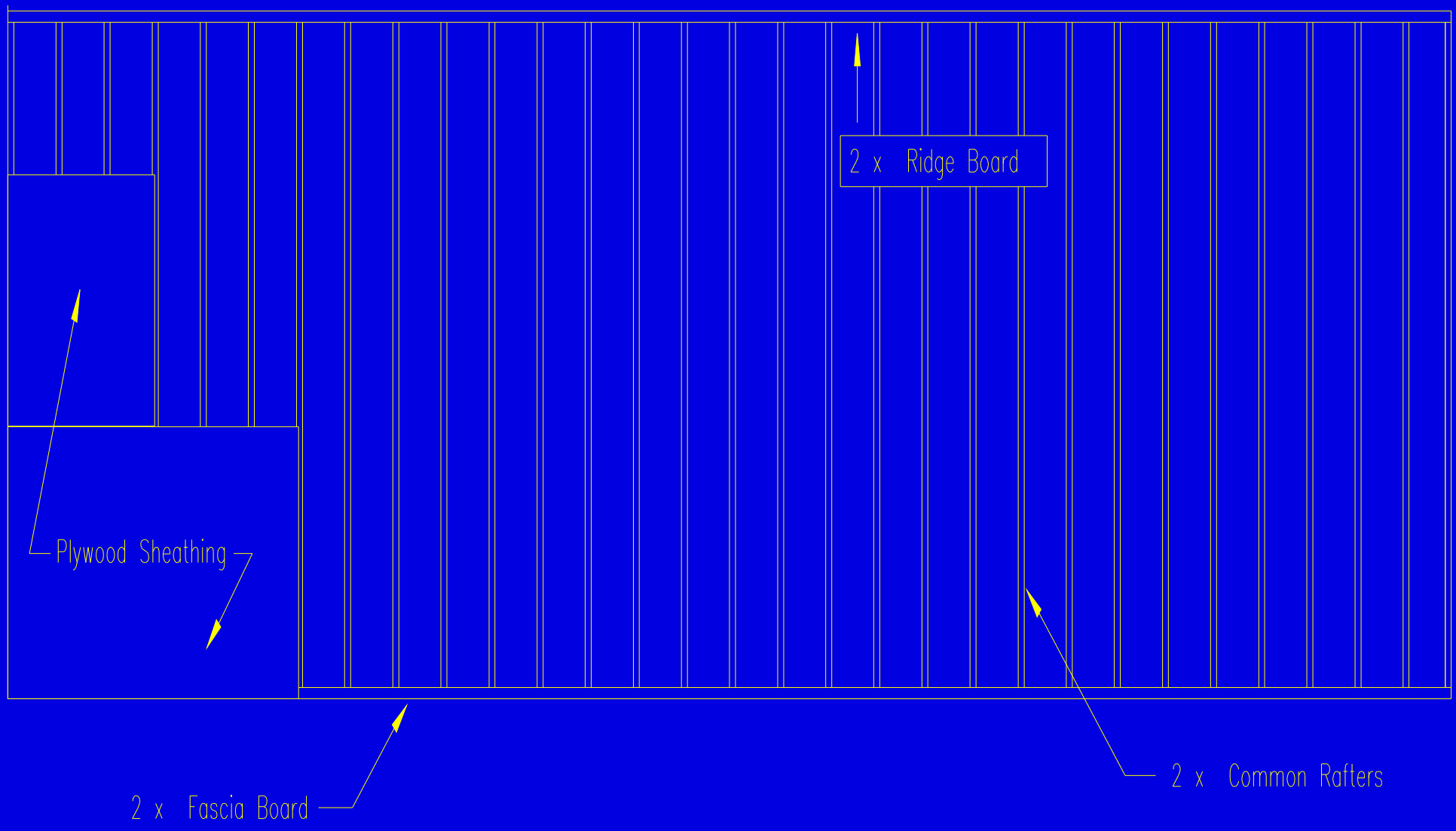
HIP ROOF FRAMING PLAN

SHED ROOF

Shed roofs have a single sloped side with vertical ends.



SHED ROOF FRAMING PLAN



SHED ROOF FRAMING PLAN

ROOF FRAMING METHODS

A roof is framed using one of two basic methods:

- Joist and rafter construction
- Truss construction

RAFTERS

- Rafters are the main framework components of all roofs.
- Normally spaced 16" or 24" o.c., their size depends on the length to be spanned, and their spacing.
- Rafters fall directly over the top of the framed-in studs so roof loads are properly transferred to the footings.

RAFTER TYPES

Rafters are seated and fastened to the wall top plate using a "birds-mouth" cut. The birds-mouth must be cut deep enough so the rafter bears on the full width of the top plate. The four types of rafters are:

- Common rafters
- Hip rafters
- Valley rafters
- Jack rafters

DEMONSTRATION

“Birds-Mouth” Cut

CEILING JOISTS

- Joist run parallel to the roof rafters and bear on the wall top plate of the exterior walls.

- The bottom of the joists provide the nailing surface for all interior spaces which call for a covered finish ceiling.

DEMONSTRATION

Collar Beam Construction

SHEATHING

- Plywood or Oriented Strand Board (OSB) is the most commonly used sheathing.
- Rafter spacing will dictate the size of plywood.
- Regardless of material it MUST run perpendicular to the rafters.

TRUSSES

- The basic shape of a truss is a rigid structural triangle.
- Trusses are lightweight framed wood members reinforced with metal or plywood gussets at webbing intersections.
- Trusses are made of smaller dimensional lumber than rafters crossing the same span.

QUESTIONS?

FRAME FINISHES

- Materials come in several classifications, we will discuss only a few as they apply to temporary structures:
- For exterior walls a , Vertical siding (T1 11) or horizontal siding (lap siding) are normally used as the exterior wall covering.
- 30 lb. Roofing felt is applied to the roof deck, then asphalt roll roofing or shingles. Galvanized flashing is applied to valleys and eave stripping is applied to all roof edges.
- Paint is another exterior material to help protect against moisture.

DOORS & WINDOWS

The following guidelines will aid in determining door and window requirements for temporary structures.

- Exterior doors are normally solid core doors.
  - **Door widths are usually 3/0 wide, and 6/8 or 7/0 tall.**
- Interior doors are normally hollow core doors.
  - **Door widths are usually 2/6 to 3/0 wide depending were they are located, and 6/8 or 7/0 tall.**
- Window types are determined by their intended use. Double-hung windows are normally used for temporary structures requiring windows.

QUESTIONS?

PRACTICAL APPLICATION

QUESTIONS?

SUMMARY

- Phases of Construction
- Construction Materials
- Dead / Live Load Calculations
- Design considerations